What is claimed is:

SUB A1

1. An optical information recording medium comprising:

a barrier layer;

a first protective layer; and

a recording layer generating a reversible phase-change which can be optically detected according to an irradiation of an energy beam; wherein said barrier layer is formed between said first protective layer and said recording layer and in contact with said first protective layer and said recording layer, and includes either one selected from the group consisting of GeN and GeNO and at least one element selected from the group consisting of Al, B, Ba, Bi, C, Ca, Ce, Cr, Dy, Eu, Ga, H, In, K, La, Mn, N, Nb, Ni, Pb, Pd, S, Si, Sb, Sn, Ta, Te, Ti, V, W, Yb, Zn and Zr.

2. The optical information recording medium according to claim 1, further comprising a second protective layer disposed at a side of said recording layer opposite to said barrier layer.

3 . The optical information recording medium according to claim 2, wherein said first protective layer and said second protective layer include a first barrier material and a second barrier material, respectively, said first and second barrier materials are represented by M_aX_b (where M denotes either one of a single non-gas element and a compound of a plurality of different non-gas elements, and X denotes either one of a single gas element and a compound of a plurality of different gas elements), and a value b/(a+b) of either one of said first and second barrier materials disposed at an energy beam-incident side of said recording layer is equal to or larger than the value of the other of said first and second barrier materials disposed at the side opposite to the energy beam-incident side.

4. The optical information recording medium according to claim 1, further comprising a reflecting layer disposed at the side of said recording layer opposite to an energy beam-incident side of said recording layer.

5. The optical information recording medium according to claim 4, further

comprising a second protective layer disposed adjacent said recording layer, wherein said second protective layer is disposed between said reflecting layer and said recording layer, and has a thickness of 60 nm or less.

6. The optical information recording medium according to claim 5, wherein said barrier layer is disposed at the energy beam-incident side of said recording layer.

7. The optical information recording medium according to claim 1, wherein said first protective layer has a thickness of 80 nm or more.

8. The optical information recording medium according to claim 1, wherein said barrier layer includes a barrier material which is either one selected from the group consisting of a nitride of a non-gas element and an oxynitride of a non-gas element.

9. The optical information recording medium according to claim 3, wherein each of said first and second barrier materials is either one selected from the group consisting of a nitride of a non-gas element and an oxynitride of a non-gas element.

10. The optical information recording medium according to claim 8, wherein said non-gas element comprises a non-gas element selected from the group consisting of Ge, Sb, Si, Zr, Ti and Al.

11 . The optical information recording medium according to claim 9, wherein said non-gas element comprises a non-gas element selected from the group consisting of Ge, Sb, Si Zr, Ti and Al.

12. The optical information recording medium according to claim 1, wherein said barrier layer includes a barrier material in which at least one selected from the group consisting of nitrogen and oxygen is less than a stoichiometric composition.

13. The optical information recording medium according to claim 1, wherein said barrier layer contains at least one element selected from the group consisting of Cr and Al and a density of said element is equal to or less than a density of a non-gas element in said barrier layer.

14. The optical information recording medium according to claim 1, further comprising: a second protective layer disposed at a side of said recording layer opposite to said barrier layer; wherein each of said first and second protective layers includes Ge, said recording layer is formed between said first and second protective layers, and a Ge density in either one of said first and second protective layers disposed at an energy beam-incident side of said recording layer is equal to or less than a Ge density in the other of said first and second protective layers disposed opposite to the energy beam-incident side of said recording layer.

15. The optical information recording medium according to claim 1, wherein said barrier layer includes Ge and a density of the Ge is in the range between 35% and 90%.

16. The optical information recording medium according to claim 1, wherein said barrier layer is disposed at an energy beam-incident side of said recording layer and includes Ge, and a Ge density of said barrier layer is in the range between 35% and 60%.

17. The optical information recording medium according to claim 1, wherein said barrier layer is disposed at a side opposite to an energy beam-incident side of said recording layer and includes Ge, and a Ge density of said barrier layer is in the range between 40% and 90%.

18. The optical information recording medium according to claim 1, wherein said barrier layer is disposed at a side opposite to an energy beam-incident side of said recording layer and includes Ge, and a Ge density of said barrier layer is in the range between 40% and 65%.

19. The optical information recording medium according to claim 2, wherein said first protective layer and said second protective layer include a first barrier material and a second barrier material, respectively, and a composition of each of said first and second barrier materials is one composition existing within a region surrounded by four composition points B1($Ge_{90.0}N_{10.0}$), B4($Ge_{83.4}N_{3.3}O_{13.3}$), G1($Ge_{35.0}N_{65.0}$), G4($Ge_{31.1}N_{13.8}O_{55.1}$) in a three element composition diagram whose vertices are Ge, N, and O.

20. The optical information recording medium according to claim 19, wherein a composition of either one of said first and second barrier materials in a layer disposed at the energy beam-incident side of said recording layer is one composition existing within a region surrounded by four composition points D1($Ge_{60.0}N_{40.0}$), D4($Ge_{48.8}N_{10.2}O_{41.0}$), G1($Ge_{35.0}N_{65.0}$), G4($Ge_{31.1}N_{13.8}O_{55.1}$) in a three element composition diagram whose vertices are Ge, N, and O.

21. The optical information recording medium according to claim 19, wherein a composition of either one of said first and second barrier materials in a layer disposed at the side opposite to the energy beam-incident side of said recording layer is one composition existing within a region surrounded by four composition points B1($Ge_{90.0}N_{10.0}$), B4($Ge_{83.4}N_{3.3}O_{13.3}$), F1($Ge_{42.9}N_{57.1}$), F4($Ge_{35.5}N_{12.9}O_{51.6}$) in a three element composition diagram whose vertices are Ge, N, and O.

22. The optical information recording medium according to claim 21, wherein said composition is one composition existing within a region surrounded by four composition points C1($Ge_{65.0}N_{35.0}$), C4($Ge_{53.9}N_{9.2}O_{36.9}$), F1($Ge_{42.9}N_{57.1}$), F4($Ge_{35..5}N_{12.9}O_{51.6}$) in a three element composition diagram whose vertices are Ge, N, and O.

23. The optical information recording medium according to claim 1, wherein a value n and a value k included in a complex refractive index n+ik of a barrier material of said barrier layer are within the range of $1.7 \leqq n \leqq 3.8$ and $0 \leqq k \leqq 0.8$, respectively.

24. The optical information recording medium according to claim 23, wherein the value n and the value k included in the complex refractive index $(n+ik)$ of said barrier material are within the range of $1.7 \leqq n \leqq 2.8$ and $0 \leqq k \leqq 0.3$, respectively.

25. The optical information recording medium according to claim 1, wherein said recording layer includes a phase-change material containing at least one of Te, Sb and Se.

26. The optical information recording medium according to claim 25, wherein said phase-change material contains Ge-Sb-Te.

27. The optical information recording medium according to claim 1, wherein said first protective layer includes an optically transparent dielectric material containing at least one element selected from the group consisting of O, S, and Se.

28. The optical information recording medium according to claim 1, wherein said barrier layer includes either one of ~~a~~ nitride and an oxynitride of at least one element constituting said recording layer.

29. A method of recording/erasing/reproducing an optical information by recording, reproducing, and erasing an optical information on the optical information recording medium as in claim 1 by irradiating a laser beam with controlling power of the laser beam.

30. An optical information recording medium comprising:

a barrier layer;

a protective layer; and

a recording layer generating a reversible phase-change which can be optically detected according to an irradiation of an energy beam; wherein said barrier layer is formed between said protective layer and said recording layer and in contact with said protective layer and said recording layer, and composed of a barrier material having a non-stoichiometric composition.

SUB A2

31. A method of recording/erasing/reproducing an optical information, comprising the steps of: providing an optical information recording medium comprising a recording layer generating a reversible phase-change which can be optically detected according to an irradiation of an energy beam, a barrier layer, and a protective layer; recording a signal to said recording layer by irradiating said recording layer with a modulated laser beam erasing a signal recorded on said recording layer by irradiating said recording layer with a laser beam having a predetermined power level; reproducing a signal recorded on said recording layer by irradiating a laser beam to said recording layer and detecting a light strength of a reflection light or a transmitted light from said recording layer; wherein said barrier layer is formed between said protective layer and said recording layer and in contact with said protective layer and said recording layer, and includes either one of GeN and GeNO and at least one element selected from the group consisting of Al, B, Ba, Bi, C, Ca, Ce, Cr, Dy, Eu, Ga, H, In , K, La, Mn, N, Nb, Ni, Pb, Pd, S, Si, Sb, Sn, Ta, Te, Ti, V, W, Yb, Zn and Zr.

32. A method of producing an optical information recording medium comprising:

a first step of forming a protective layer;

a second step of forming a recording layer generating a reversible phase-change which can be optically detected according to an irradiation of an energy beam, and

a third step of forming a barrier layer by a high-frequency sputtering method in an atmosphere containing rare gas using a target containing a barrier material.

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33. The method according to claim 32, further comprising a fourth step of forming a protective layer at one side of said recording layer by a high-frequency sputtering method in an atmosphere containing rare gas using a target containing a barrier material.

34. The method according to claim 33, wherein said target used in said fourth step is made of a barrier material.

35. The method according to claim 32, wherein said target includes at least one selected from the group consisting of a non-gas component of said barrier material, a nitride of said non-gas component, an oxynitride of said non-gas component, and an oxide of said non-gas component.

36. The method according to claim 32, wherein said barrier layer is formed by a reactive sputtering method performed in an atmosphere containing a mixed gas containing rare gas and nitrogen component.

37. The method according to claim 32, wherein said protective layer is formed by a reactive sputtering method performed in an atmosphere containing a mixed gas containing rare gas and nitrogen component.

38. The method according to claim 32, wherein said rare gas contains at least one of Ar and Kr.

39. The method according to claim 32, wherein a first layer at an energy beam-incident side of said recording layer and a second layer at a side of said recording layer opposite to said energy beam-incident side are formed in a sputter atmosphere gas, and a nitrogen partial pressure in the sputter atmosphere gas for forming said first layer is higher than a nitrogen partial pressure in the sputter atmosphere gas for forming said second layer.

40. The method according to claim 32, wherein at least one of said barrier layer and said protective layer includes a barrier material and formed by a reactive sputtering method, and a non-gas component of said barrier material is Ge.

41. The method according to claim 40, wherein said target includes an element selected from the group consisting of Ge_3N_4-GeO, GeO, GeO_2, Ge_3N_4-GeO and Ge_3N_4-GeO_2.

42. The method according to claim 40, wherein said reactive sputtering is

carried out in an atmosphere gas whose total pressure is in the range between 1 mTorr and 50 mTorr.

43. The method according to claim 40, wherein an atmosphere gas used in said reactive sputtering is a mixed gas containing rare gas and N_2, and a partial pressure ratio of N_2 is in the range between 10% and 66%.

44. The method according to claim 43, wherein said partial pressure ratio of N_2 is in the range between 10% and 50%.

45. The method according to claim 40, wherein a power density of said reactive sputtering is higher than 1.27 W/cm^2, and the sputter atmosphere contains a mixed gas including rare gas and N_2.

46. The method according to claim 42, wherein a sputter rate of said reactive sputtering is more than 18 nm/minute.

47. The method according to claim 40, wherein a complex refractive index value n+ik of at least one of said barrier layer and said protective layer is in the range between $1.7 \leqq n \leqq 3.8$ and $0 \leqq k \leqq 0.8$.

48. The method according to claim 32, wherein said target is a single target comprises at least one of an element included in said recording layer, a nitride of an element included in said recording layer, an oxynitride of an element included in said recording layer, and a oxide of an element included in said recording layer, and the sputter atmosphere gas includes rare gas and one of nitrogen component and oxygen component.

49. The method according to claim 32, wherein said target is same as a target used for forming said recording layer, and one of partial pressure of gas containing nitrogen component and a partial pressure of gas containing oxygen component in the sputtering atmosphere is increased.

SUB B3

50. An optical information recording medium comprising a phase-change

recording layer having reversibly changeable optical characteristics and a Ge-containing layer comprising either one selected from the group consisting of GeXN and GeXON as a main component,

wherein X is at least one element selected from the group consisting of elements belonging to Groups IIIa, IVa, Va, VIa, VIIa, VIII, Ib and IIb and C.

51. The optical information recording medium according to claim 50, wherein the Ge-containing layer is in contact with at least one surface of the phase-change recording layer.

52. The optical information recording medium according to claim 50, the medium comprising a first Ge-containing layer and a second Ge-containing layer, the first Ge-containing layer and the second Ge-containing layer comprising either one selected from the group of GeXN and GeXON as a main component,

wherein X is at least one element selected from the group consisting of elements belonging to Groups IIIa, IVa, Va, VIa, VIIa, VIII, Ib and IIb and C,

the phase-change recording layer having a first surface on which laser beams are incident in use and a second surface on the other side,

wherein the first Ge-containing layer in contact with the first surface and the second Ge-containing layer is in contact with the second surface.

53. The optical information recording medium according to claim 52, wherein the content of X in the first Ge-containing layer is different from the content of X in the second Ge-containing layer.

54. The optical information recording medium according to claim 52, wherein the first Ge-containing layer has a composition represented by $(Ge_{1-m}X_m)_aO_bN_c$ ($0 < m < 1$, $a > 0$, $b \geqq 0$, $c > 0$, $a + b + c = 100$), and the second Ge-containing layer has a composition represented by $(Ge_{1-n}X_n)_dO_eN_f$ ($0 < n < 1$, $d > 0$, $e \geqq 0$, $f > 0$, $d + e + f = 100$), and the following inequality is satisfied: $m < n$.

55. The optical information recording medium according to claim 50,

wherein a composition ratio of Ge and X in the Ge-containing layer is represented by $Ge_{1-k}X_k$ $(0 < k \leqq 0.5)$.

56. The optical information recording medium according to claim 50, wherein a composition ratio of (GeX), O and N in the Ge-containing layer has numerical values which lie within the range represented by the area ABDC in a ternary phase diagram of (GeX), O and N, where the points A, B, C and D are as follows:

A $((GeX)_{90.0}O_{0.0}N_{10.0})$, B $((GeX)_{83.4}O_{13.3}N_{3.3})$,
C $((GeX)_{35.0}O_{0.0}N_{65.0})$, D $((GeX)_{31.1}O_{55.1}N_{13.8})$.

57. The optical information recording medium according to claim 56, wherein a composition ratio of Ge and X in the Ge-containing layer is represented by $Ge_{1-p}X_p$ $(0 < p \leqq 0.5)$.

58. The optical information recording medium according to claim 50, wherein a thickness of the Ge-containing layer is at least 1 nm.

59. The optical information recording medium according to claim 50, wherein X is at least one element selected from the group consisting of Cr, Mo and Mn.

60. The optical information recording medium according to claim 50, wherein X is at least one element selected from the group consisting of Ti, Zr, Nb and Ta.

61. The optical information recording medium according to claim 50, wherein X is at least one element selected from the group consisting of Fe, Co and Ni.

62. The optical information recording medium according to claim 50, wherein X is at least one element selected from the group consisting of Y and La.

63. The optical information recording medium according to claim 50, wherein the phase-change recording layer comprises a phase-changeable material including any one selected from the group consisting of Te, Se and Sb as a main component.

64. The optical information recording medium according to claim 50, wherein the phase-change recording layer comprises a phase-changeable material including Te, Sb and Ge as a main component.

~~65. A method for producing an optical information recording medium comprising the steps of: forming a phase-change recording layer having reversibly changeable optical characteristics; and forming a Ge-containing layer comprising either one selected from the group consisting of GeXN and GeXON as a main component, where X is at least one element selected from the group consisting of elements belonging to Groups IIIa, IVa, Va, VIa, VIIa, VIII, Ib and IIb and C,~~

~~wherein the Ge-containing layer is produced by reactive sputtering with a target including at least Ge and X in a mixed gas comprising a rare gas and nitrogen.~~

~~66. The method for producing an optical information recording medium according to claim 65, wherein the mixed gas further comprises oxygen.~~

~~67. The method for producing an optical information recording medium according to claim 65,~~

~~the method comprising a first step of forming a first Ge-containing layer, a second step of forming a phase-change recording layer having reversibly changeable optical characteristics on the first Ge-containing layer, and a third step of forming a second Ge-containing layer on the phase-change recording layer,~~

~~wherein a content ratio of nitrogen in the mixed gas in the first step is different from a content ratio of nitrogen in the mixed gas in the third step.~~

~~68. The method for producing an optical information recording medium~~

according to claim 67, wherein a content ratio of nitrogen in the mixed gas in the first step is larger than a content ratio of nitrogen in the mixed gas in the third step.

69. The method for producing an optical information recording medium according to claim 65,

wherein a first step of forming a first Ge-containing layer, a second step of forming a phase-change recording layer having reversibly changeable optical characteristics on the first Ge-containing layer, and a third step of forming a second Ge-containing layer on the phase-change recording layer are performed in this order, and

a composition ratio of Ge and X in the target used in the first step is represented by $Ge_{1-m}X_m$ and a composition ratio of Ge and X in the target used in the third step is represented by $Ge_{1-n}X_n$, and the following inequality is satisfied: $m < n$, where $0 < m < 1$, $0 < n < 1$.

70. The method for producing an optical information recording medium according to claim 65, wherein the target includes a mixture of Ge and X.

71. The method for producing an optical information recording medium according to claim 65, wherein the target includes an alloy of Ge and X.

72. The method for producing an optical information recording medium according to claim 65, wherein a total pressure of the mixed gas is at least 1.0mTorr.

73. The method for producing an optical information recording medium according to claim 65, wherein a partial pressure of nitrogen in the mixed gas is at least 10%.

74. The optical information recording medium according to claim 51, wherein the Ge-containing layer prevents atoms from diffusing between the phase-change recording layer and a layer adjacent to the recording layer.

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